

Weed-Control Systems for Peanut Grown as a Biofuel Feedstock

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Peanuts are not often used as a true oilseed crop, especially for the production of fuel. However, peanut could be a feedstock for biodiesel, especially in on-farm or small cooperative businesses, where producers can dictate the cost of making their own fuel. Field studies were conducted in 2005 and 2006 to assess low-cost weed-control systems for peanuts that would facilitate the economic viability of peanut biodiesel. Four preselected herbicide costs ranging from \$25 to \$62/ha and two application timings were compared with nontreated (\$0/ha) and typical (\$115/ha) herbicide programs for weed control and peanut oil yield. A peanut oil yield goal of 930 L/ha was exceeded with multiple low-cost herbicide systems in 3 of 4 site-yr. The main effect of application timing was only significant for a single site-year in which oil yield increased linearly with cost of the PRE and POST weed-control system. An herbicide cost of \$50/ha, using PRE and POST applications, was consistently among the highest in oil yield, regardless of site-year, exceeding the typical (high value) programs in 3 of 4 site-yr. Use of reduced rates of imazapic (0.5× or 0.035 kg ai/ha) was detrimental in 2 of 4 site-yr. Weed control, and thus oil yields, were most dependent on species present at each location and not on input price. Data from this series of studies will allow researchers and entrepreneurs to more accurately assess the viability and sustainability of peanut biodiesel.

Nomenclature: Imazapic; peanut, *Arachis hypogaea* L.

Key words: Biodiesel, conservation tillage, herbicide, low-cost, low-input, reduced rates, sustainable agriculture, alternative fuels.

Soybean [*Glycine max* (L.) Merr.] is the primary oilseed used in U.S. biodiesel production at present. However, soybean contains only 18 to 25% oil in comparison to peanut kernels, which are approximately 50% oil by weight (Davis et al. 2007; Khan and Hanna 1983). Given an average peanut yield of 3,140 kg/ha (USDA 2007a), greater than 1,000 L/ha oil yield could be expected. This is significant considering that, in the southeastern United States, peanuts will produce nearly 50% more oil per unit area than soybean (Kurki et al. 2006).

Peanuts are a crop with high oil value, but the production of peanuts solely for oil has not been emphasized in the United States. Therefore, the success of peanut as a feedstock for biodiesel hinges on low-input production at the farm level and a marketing system that bypasses traditional food-grade procedures that add excess value to the oil. Food-grade peanut production under the current marketing loan system precludes production specifically for the oil market. The result is oil valued at > \$0.88/kg when compared with more common vegetable oils like soybean or canola (*Brassica napus* L.) that have traditionally traded at approximately \$0.55 and \$0.65/kg, respectively. Given the fact that peanut oil weighs 0.9 kg/L, peanut biodiesel prices would begin at \$0.79/L plus processing costs. At these prices, peanut oil is only marginally competitive with petroleum-based fuel and is not competitive with soybean or canola. However, the recent interest in ethanol production from grain has driven corn (*Zea mays* L.) prices to record levels, thus affecting other commodities like soybean oil, which is trading at the same price as peanut oil (USDA 2007b). Despite

the recent increase in oil value, if farmers could develop on-farm processing and handling of oilseeds, the value of peanut and other oils would be retained on the farm, and producers might have an opportunity to become more fuel independent.

On-farm production of biodiesel from peanut requires minimal change to existing farm machinery. For example, the infrastructure exists for the shelling and storage of peanuts locally, and oil presses can be purchased for about \$10,000 per unit. Thus, a new production system that emphasizes oil production should be investigated. Of utmost importance in these low-input production systems will be pairing cultivars with favorable oil chemistry and tolerance to common diseases with production practices that increase oil or minimize variable costs. Peanut cultivars with high tolerance to the complex of diseases are rapidly being developed to satisfy demand for organically grown peanuts. These cultivars show increased levels of resistance to spotted wilt, caused by Tomato spotted wilt virus (TSWV); early leaf spot, caused by *Cercospora arachidicola*; late leaf spot, caused by *Cercosporidium personatum*; and whitemold, caused by *Sclerotium rolfsii* (Cantonwine et al. 2006; Culbreath et al. 2003). If these disease-resistant cultivars are planted, weed control would most likely be the most costly production input.

Peanut production systems tailored to the biodiesel market must decrease input costs to maintain competitiveness with petroleum fuels. Use of disease-resistant cultivars could save as much as \$217/ha through the elimination of fungicide sprays, whereas increasing thresholds of insect tolerance could save another \$103/ha when insecticide use is decreased (UGA 2007). Limited research exists for low-input weed control in peanut.

Peanut weed management can cost as much as \$115/ha (UGA 2007) and use five to seven different herbicides applied at three or four times from preplant to late POST (Grichar et al. 2005; Wilcut et al. 1995). A dinitroaniline herbicide, such

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as pendimethalin or ethalfluralin, is commonly applied PPI or PRE to control annual grass species, such as Texas panicum (*Panicum texanum* Buckl.) (Grey and Wehtje 2005). POST weed control more commonly includes paraquat, bentazon, 2,4-DB, and imazapic (Wilcut et al. 1995), and use of these and other herbicides is based on the weed spectra present in each field. Numerous combinations of the previously mentioned herbicides are possible, and some research has addressed the economics of such combinations (Clewis et al. 2002; Grichar et al. 2005; Scott et al. 2002; Wilcut 1991a,b). However, few have investigated reduced rates of herbicides as a means of saving on input costs. Troxler et al. (2001) reported that 0.5× rates of imazapic (0.035 kg/ha) gave control of certain broadleaf weeds similar to the 1× rate. More information is needed on combinations of low-cost herbicides and reduced rates of more expensive herbicides that will still provide adequate weed control.

Twin-row spacing and cover crops have been investigated as tools to reduce herbicide inputs with mixed results. Most agree that peanut yields are increased in twin rows; however, herbicide use was not reduced (Brecke and Stephenson 2006; Cardina et al. 1987; Colvin et al. 1985; Hauser and Buchanan 1981; Wehtje et al. 1984). Cover crops have demonstrated some utility in suppressing weeds and possibly reducing herbicide inputs in both soybean and peanut (Price et al. 2006, 2007).

The primary objective of this research project was to investigate low-cost weed-control programs for peanuts grown for oil production. As opposed to other low-cost weed-control studies for edible peanut production, costs for weed control were preselected with the understanding that weed thresholds may or may not be met. The primary importance of this work is to generate data that will determine costs of weed control in systems that can be used to develop business models and conduct further feasibility studies into peanut biodiesel.

Materials and Methods

Field studies were conducted, during 2005 and 2006, at the National Peanut Research Laboratory in Dawson, GA; during 2005, at the Pee Dee Research and Education Center in Florence, SC; and during 2006, at the Plant Science Research and Education Unit in Citra, FL. Peanut was planted in four-row plots by 7.6 or 9.2 m in length, depending on location. Row spacing varied by location from a narrower 76 cm at Citra, to 91 and 97 cm at Dawson and Florence, respectively. Peanut was strip-tilled into a terminated rye (*Secale cereale* L.) cover crop at both Citra and Dawson; however, the Florence location was planted into a stale seedbed. The Citra location was under supplemental irrigation, whereas both Dawson and Florence were rain fed only. Soils were typical of the U.S. peanut belt, ranging from loamy sand (Florence) to fine sand (Citra). Weed species present at Citra included sicklepod [*Senna obtusifolia* (L.) H.S. Irwin & Barneby], hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. ex A.W. Hill], and ivyleaf morningglory (*Ipomoea hederacea* Jacq.). The perennial grasses, bahiagrass (*Paspalum notatum* Fluegge) and common bermudagrass [*Cynodon dactylon* (L.) Pers.], were

present, along with Palmer amaranth (*Amaranthus palmeri* S. Wats.) at Dawson. Palmer amaranth was also present at Florence along with large crabgrass [*Digitaria sanguinalis* (L.) Scop.].

Because of the economic constraints previously described, peanut for biofuel feedstock must be grown in a low-cost agronomic system to be competitive with petroleum diesel. Thus, the following protocol was established for each site-year: (1) selection of a highly disease-resistant cultivar, (2) elimination of fungicide application, (3) insecticide application used only under extreme conditions, and (4) all inputs closely monitored and recorded. The peanut cultivar 'DP-1'¹ was selected for all 4 site-yr. DP-1 is a cultivar that has superior yield capability, combined with resistance to leaf spot and whitemold and moderate tolerance to TSWV (Cantonwine et al. 2006). In addition to these agronomic traits, DP-1 has 3 to 5% greater oil content than most other peanut cultivars (Davis et al. 2007) and has been found to be among the highest cultivars in peanut oil production in previous field trials (Faircloth et al. 2007). DP-1 seed for all 4 site-yr came from the same lot to ensure consistent agronomic performance across locations.

Treatments were arranged in a four by two factorial of weed-control cost ($n = 4$) by application timing ($n = 2$) in a randomized complete-block design with four replications. Herbicides costs were \$25, \$37, \$50, and \$62/ha. Application timings were either POST only or PRE and POST. Specific herbicide treatments were combinations of herbicides that equaled the preselected costs. Two treatments, not part of the factorial, were included for comparison: a nontreated control and a typical (high-input) peanut herbicide control program. A full listing of treatments and herbicides is given in Table 1. Herbicides were applied at each location with a CO₂-powered backpack or tractor-mounted sprayer, calibrated to deliver between 168 to 225 L/ha, depending on location.

Data collection included peanut yield and visual estimations of weed control. Weed control was visually rated on a scale of 0 to 100, with 0 being no control and 100 being complete plant death. Yield samples were dried to 10% moisture and shipped to Dawson, GA, where a random 500-g subsample was obtained for grade analysis. In addition, random kernel samples were obtained from grade samples from each site-year and analyzed in triplicate for oil content. Oil yields were determined using the following equation:

$$y = \text{yield} \times \text{grade} \times \text{kernel oil content} \times 0.9 \quad [1]$$

where *yield* equals farmer stock yield (kg/plot), *grade* equals the percentage of all kernels that will not pass through a 4 by 19 mm slotted screen (less foreign material and hulls as determined by official grade sampling) (USDA 1993), and *kernel oil content* equals average percentage of oil content per site-year as determined by pulsed-proton nuclear magnetic resonance (NMR)² (Rubel 1994). A correction factor of 0.9 was added to the calculation, assuming that only 90% of the actual kernel oil content could be extracted using mechanical means (Adeeko and Ajibola 1990; Khan and Hanna 1983; Sivakumaran et al. 1985). Plot oil yields (*y*) were expressed as liters per hectare. A yield goal of 930 L/ha (100 gal/acre) was

Table 1. Treatment descriptions and herbicides used in a low-input biofuel peanut study.^a

Cost	Description	POST herbicides	Rate
\$/ha			kg/ha
\$25.00	POST only	Paraquat + 2,4-DB fb imazapic	0.14 + 0.25 fb 0.035
\$37.00	POST only	Paraquat + bentazon fb imazapic	0.14 + 0.56 fb 0.035
\$50.00	POST only	Paraquat + imazapic	0.14 + 0.071
\$62.00	POST only	Paraquat + 2,4-DB fb acifluorfen fb imazapic	0.14 + 0.25 fb 0.28 fb 0.035
\$25.00	PRE + POST ^b	Imazapic	0.035
\$37.00	PRE + POST	Paraquat + 2,4-DB fb imazapic	0.14 + 0.25 fb 0.035
\$50.00	PRE + POST	Imazapic	0.071
\$62.00	PRE + POST	Paraquat + bentazon fb imazapic	0.14 + 0.56 fb 0.071
\$0.00	Nontreated	None	n/a
\$115.00	Typical ^c	Paraquat fb imazapic + 2,4-DB fb acifluorfen	0.14 fb 0.071 + 0.25 fb 0.28

^a Abbreviation: fb = followed by; n/a, not applicable.

^b PRE herbicide, pendimethalin (0.92 kg/ha).

^c PRE, pendimethalin (0.92 kg/ha) + diclosulam (0.026 kg/ha).

determined to be an economically viable yield goal for on-farm fuel production (W. H. Faircloth, unpublished data).

Data for oil yield and weed control were subjected to mixed models analysis techniques to determine significance of main effects and their interactions (SAS 2002). The two comparison treatments (nontreated and typical herbicide program) were excluded from factorial analysis. Linear regression was performed on oil yield and herbicide costs. Means for oil yield and weed control were separated where appropriate using Duncan's multiple range test at $P = 0.05$. In addition to the above statistical procedures, three nonorthogonal contrasts were identified: (1) all treated plots vs. the nontreated control, (2) all low-input treatments vs. a typical high-input herbicide program, and (3) imazapic at $0.5\times$ (0.035 kg/ha) vs. imazapic at $1\times$ (0.71 kg/ha).

Results and Discussion

ANOVA results of peanut oil yields revealed that the two-way interaction between location and treatment was highly significant (< 0.0001) (data not shown). In addition, weed species differentiation between locations warrants data being presented by location.

Citra. ANOVA of peanut oil yields showed significant main effects for cost, but not for application timing; however, the interaction of cost by application was significant (Table 2).

Table 2. ANOVA results by location for peanut oil yield in a low-input biofuel weed-control study.^a

Source	Citra	Dawson	Florence
	$P > F^b$		
Year	n/a	0.2274	n/a
Cost	< 0.0001	0.1021	0.0007
Application	0.4172	0.4801	0.0003
Cost \times application	0.0131	0.5236	0.0360
Treatment	< 0.0001	0.2557	$< .0001$

^a Location by treatment interaction was highly significant ($P < .0001$); therefore, results were presented by location; n/a, not applicable.

^b Main effects and interactions were considered significant if $P \leq 0.05$.

Accordingly, both oil yield and weed-control data are presented by cost and application.

Oil yield at Citra was the lowest of any of the 3 site-yr, ranging from 40 to 870 L/ha (Table 3). No herbicide system, including the typical program, exceeded the preselected yield goal of 930 L/ha. This is possibly due to the presence and density of three highly competitive broadleaved weeds: sicklepod, hemp sesbania, and ivyleaf morningglory (Wilcut et al. 1995). The lack of annual grass species likely decreased the importance of pendimethalin applied PRE, thereby, resulting in equal yield and weed control with or without pendimethalin (Grey and Wehtje 2005). Increasing the investment in weed-control costs resulted in greater weed control and higher oil yield in POST-only systems, but not in PRE and POST systems (Figure 1).

Higher costs did not always equal high oil yields as in the \$62.00 PRE and POST treatment that included bentazon. Also, the POST-only treatment of paraquat and bentazon followed by (fb) imazapic ($0.5\times$) yielded equal to the nontreated control (Table 3). Both treatments led to poor hemp sesbania control. Bentazon is a costly herbicide that does not control hemp sesbania (Reddy et al. 1995). Generally, the use of 2,4-DB was superior as a tank-mix partner with paraquat as opposed to bentazon. Significantly greater control of hemp sesbania and highest oil yields were obtained with paraquat and 2,4-DB fb acifluorfen fb imazapic ($0.5\times$) or paraquat and bentazon fb imazapic. The use of imazapic at the full rate, regardless of pendimethalin usage, resulted in highest oil yields. Contrasts support imazapic at the $0.5\times$ rate decreasing oil yield by 310 L on average and resulting in an 8 to 23% reduction in weed control (Table 3). Therefore, for this particular spectrum of weeds, the use of $0.5\times$ rates of imazapic did not provide an economic return. This was most likely because other herbicides, such as acifluorfen were required to obtain highest oil yields, thus the $0.5\times$ imazapic rate actually increased costs vs. the full rate of imazapic applied alone. Contrasts also demonstrated that low-input systems as described here yielded 410 L/ha less than a typical high-input herbicide system.

Dawson. ANOVA for oil yield showed no significant main effects or interactions (Table 2). Additionally, year was not a

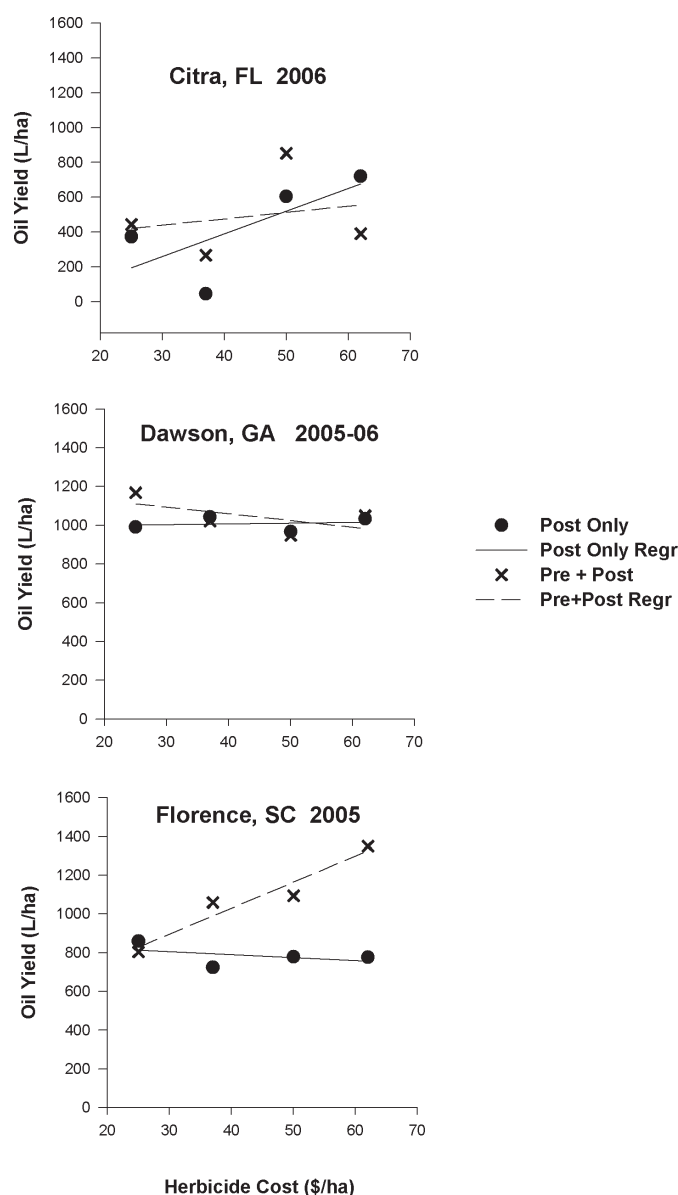


Figure 1. Peanut oil yield as a function of herbicide cost and application timing. Increasing herbicide cost was significantly correlated with increased yield in 1 of 4 site-yr: Florence, PRE and POST ($R^2 = 0.92$).

significant effect at this location, and data from 2005 and 2006 were pooled for analysis (Table 2). Two of three weed species did show significant differences among treatments; therefore, data are presented by cost and application timing (treatment).

Oil yield at Dawson had a mean of 1,013 L/ha and a range of only 340 L (Table 4). All treatments, except the typical program, exceeded the 930 L/ha yield goal. No significant differences in oil yield were detected among treatments, including all treated plots vs. the nontreated control. Oil yield showed no trends according to input costs (Figure 1). Low-input treatments did show a 200-L increase ($P = 0.0199$) vs. the typical herbicide system. PRE and POST systems showed a slight (40 L/ha), but nonsignificant, increase in oil yield as opposed to POST-only systems ($P = 0.4939$). This finding

does not confirm most studies, which would favor PRE applications of pendimethalin for control and suppression of grass species (Grey and Wehtje 2005; Wilcut et al. 1995). However, the crop rotation at the Dawson location (peanuts following > 2 yr of unimproved mixed-species pasture) would indicate that common bermudagrass and bahiagrass arise from vegetative propagules rather than from seed. The lack of differences in oil yield was not expected given that there were significant differences in response of both bermudagrass and Palmer amaranth between treatments. Understandably, contrasts revealed large differences in weed control between treated and nontreated plots. Imazapic and paraquat applied POST controlled Palmer amaranth 85%. Paraquat and bentazon did not provide acceptable control of common bermudagrass; however, bentazon increased control of Palmer amaranth to 100% vs. paraquat and 2,4-DB. The addition of bentazon, 2,4-DB, or 2,4-DB fb acifluorfen to paraquat fb imazapic resulted in 100% Palmer amaranth control. The 0.5× rate of imazapic increased oil yield by 100 L as compared with the full 1× rate. This anomaly cannot be explained because the three primary weed species generally did not respond to this herbicide.

Florence. ANOVA for oil yield indicated significant main effects for both cost and application timing and their interaction (Table 2). Weed-control ratings also showed significant treatment differences; therefore, data are presented by cost and application.

All treated plots yielded 510 L greater than the nontreated control (Table 5). However, no significant differences existed between any low-input systems and the typical herbicide system. Three low-input herbicide programs in the PRE and POST application category, ranging from \$37 to \$62/ha, exceeded the 930 L/ha threshold. The addition of pendimethalin to treatments increased oil yield 290 L on average ($P = 0.0003$); however, not all PRE and POST systems increased oil yield. The former demonstrates the value of large crabgrass control with pendimethalin. Large crabgrass control ratings were significantly greater in PRE and POST systems vs. POST-only systems. Palmer amaranth control was at least 89% with all treatments except pendimethalin fb imazapic (0.5×). This is likely due to delay in application of imazapic, whereas other treatments received early POST application of paraquat tank mixes. Contrasts showed a detrimental effect of using 0.5× rates of imazapic; oil yield decreased 210 L/ha, Palmer amaranth control decreased 9%, and large crabgrass control decreased 18%. Oil yield showed a strong linear relationship ($R^2 = 0.92$) with herbicide costs for the PRE and POST systems, but not for the POST-only systems (Figure 1). Large crabgrass was not controlled in POST-only systems because of the lack of pendimethalin (Table 5). Imazapic has shown inconsistent control of large crabgrass applied POST (Burke et al. 2004) but after providing initial control of emerged seedlings, it did not prevent reinfestation at Florence. Much prior research indicates the competitiveness of annual grasses, such as large crabgrass, with peanut and further relates to the ease of control with dinitroaniline herbicides (Grey and Wehtje 2005). Palmer amaranth control was in the good to excellent range with either POST-only or PRE and POST systems, except for the treatment containing

Table 3. Peanut oil yield and weed control in a low-input biofuel weed-control system; Citra, FL 2006.

Cost	Application ^a	Oil yield ^b	Sicklepod	Morningglory	Hemp sesbania
\$/ha		L/ha		%	
\$25.00	POST only	370 cd	88 a	88 a	89 ab
\$37.00	POST only	40 e	74 bc	75 b	10 c
\$50.00	POST only	600 abc	88 a	83 ab	67 b
\$62.00	POST only	720 ab	93 a	95 a	99 a
\$25.00	PRE + POST	440 bcd	63 c	63 c	10 c
\$37.00	PRE + POST	270 de	93 ab	93 a	89 ab
\$50.00	PRE + POST	850 a	90 a	90 a	84 ab
\$62.00	PRE + POST	390 cd	89 ab	89 a	81 ab
\$0.00	Nontreated ^c	40	0	0	0
\$115.00	Typical program	870	91	95	95
Contrast			Estimate ^d		
Treated vs. nontreated		+470 0.0001	+84 < 0.0001	+86 < 0.0001	+69 0.0057
All low input vs. typical		-410 0.0002	-7 0.0503	-10 0.2047	-29 0.4774
Imazapic 0.5× vs. 1×		-310 0.4172	-8 0.1098	-20 0.0991	-23 0.5337

^a Table 1 shows specific PRE and POST herbicide systems.

^b Treatment means within a column followed by the same letter are not statistically different according to Duncan's Multiple Range Test (MRT) (P = 0.05).

^c Nontreated and typical programs excluded from means separation test.

^d Values are the estimated mean differences followed by respective contrast P-values.

pendimethalin fb imazapic at the 0.5× rate. Similarly, all treatments that used imazapic 0.5× were 210 L/ha lower in oil production vs. imazapic at 1×. This was likely a direct result of a 9 and 18% decrease in Palmer amaranth and large crabgrass control, respectively.

Collectively, these data indicate that low-cost herbicide systems can be implemented; however, some yield loss can be expected. A yield goal of 930 L/ha was obtained in 3 of 4 site-yr, indicating success could be found in low-cost biodiesel style production systems. Individual producers must carefully consider the loss of yield vs. the decrease in inputs to evaluate the utility of such systems. The linear relationship between cost and oil yield was not always apparent, with success depending on herbicide selection according to weed species present. For example, if annual grass species are expected, a PRE application of pendimethalin is valuable. However, if perennial grasses or large-seeded broadleaf

weeds dominate, that input cost may be reallocated to increase POST control with more effective herbicides.

At two of three locations, the use of 0.5× rates of imazapic was not advised because of inadequate weed control and subsequent losses in oil yields. Other factors, such as herbicide resistance, must also be considered before using less-than-normal use rates of some herbicides. For example, repeated usage of sublethal rates of glyphosate is proposed to be one of several processes contributing to development of glyphosate-resistant Palmer amaranth (Culpepper et al. 2006; Vencill et al. 2008). Imazapic, which is an acetolactate synthase (ALS)-inhibiting herbicide, must be used judiciously given the propensity of this class of herbicides to exert strong selection pressure because of high activity on sensitive weeds and soil residual properties when compared with other classes of herbicides (Tranel and Wright 2002). In general, bentazon

Table 4. Peanut oil yield and weed control in a low input biofuel weed-control system; Dawson, GA.

Cost	Application ^a	Oil yield ^b	Common bermudagrass	Bahiagrass	Palmer amaranth
\$/ha		L/ha		%	
\$25.00	POST only	990 a	90 a	93 a	76 b
\$37.00	POST only	1,040 a	79 ab	91 a	100 a
\$50.00	POST only	970 a	92 a	92 a	85 ab
\$62.00	POST only	1,030 a	85 a	93 a	100 a
\$25.00	PRE + POST	1,170 a	78 ab	84 a	98 a
\$37.00	PRE + POST	1,020 a	88 a	83 a	100 a
\$50.00	PRE + POST	950 a	85 a	86 a	81 b
\$62.00	PRE + POST	1,050 a	60 b	88 a	100 a
\$0.00	Nontreated ^c	1,080	0	0	0
\$115.00	Typical program	830	90	97	100
Contrast			Estimate ^d		
Treated vs. nontreated		-70 0.3485	+83 < 0.0001	+90 < 0.0001	+93 0.0057
All low input vs. typical		+200 0.0199	-7 0.3405	-8 0.2047	-7 0.4774
Imazapic 0.5× vs. 1×		+100 0.4939	+2 0.1123	-2 0.0991	+3 0.5337

^a Table 1 shows specific PRE and POST herbicide systems.

^b Treatment means within a column followed by the same letter are not statistically different according to Duncan's Multiple Range Test (MRT) (P = 0.05).

^c Nontreated and typical programs excluded from means separation test.

^d Values are the estimated mean differences followed by respective contrast P values.

Table 5. Peanut oil yield and weed control in a low input biofuel weed-control system; Florence, SC, 2005.

Cost	Application ^a	Oil yield ^b	Palmer amaranth	Large crabgrass			
\$/ha		L/ha	%				
\$25.00	POST only	860 bc	97 a	48 cd			
\$37.00	POST only	730 c	89 a	31 d			
\$50.00	POST only	780 bc	94 a	45 cd			
\$62.00	POST only	780 bc	96 a	58 c			
\$25.00	PRE + POST	810 bc	58 b	83 b			
\$37.00	PRE + POST	1,060 ab	89 a	90 a			
\$50.00	PRE + POST	1,090 ab	92 a	88 ab			
\$62.00	PRE + POST	1,350 a	96 a	88 ab			
\$0.00	Nontreated ^c	430	0	0			
\$115.00	Typical program	1,010	98	99			
Contrast			Estimate ^d				
Treated vs. nontreated		+510	< 0.0001	+70	< 0.0001		
All low input vs. typical		−80	0.4629	−9	0.0204	−33	0.0145
Imazapic 0.5× vs. 1×		−210	0.0003	−9	0.0004	−18	< 0.0001

^aTable 1 shows specific PRE and POST herbicide systems.

^bTreatment means within a column followed by the same letter are not statistically different according to Duncan's Multiple Range Test (MRT) (P = 0.05).

^cNontreated and typical programs excluded from means separation test.

^dValues are the estimated mean differences followed by respective contrast P values.

neither increased weed control nor oil yield when compared with other herbicides like 2,4-DB and acifluorfen.

Importantly, herbicide selection should be site specific and be chosen in response to previous infestations. Producers considering biodiesel production systems should carefully consider yield potential, weed spectrum, and application costs before selecting a budget for weed control. Elimination of fungicides and limited insecticide applications could limit peanut yield potential; thus, the interaction of reducing herbicides with diminished yield potential needs investigating. The low-cost herbicide systems described in this project can be used effectively, and these data will be useful in forming business models for on-farm and cooperative-style biodiesel production facilities.

Sources of Materials

¹ DP-1 peanut, Florida Foundation Seed, Marianna, FL 32446.

² Maran Pulsed NMR, Resonance Instruments, Witney, Oxfordshire OX29 4BP, UK.

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